

Space Heating in Swine Production



Introduction

On average, 95% of the natural gas consumption in a swine operation is attributed to space heating (Figure 1). This equates to 608 Gigajoules (GJ) for a 500 sow farrow-to-wean operation. Assuming the cost of natural gas is \$5.50 per GJ, this equates to \$3,344 per year.

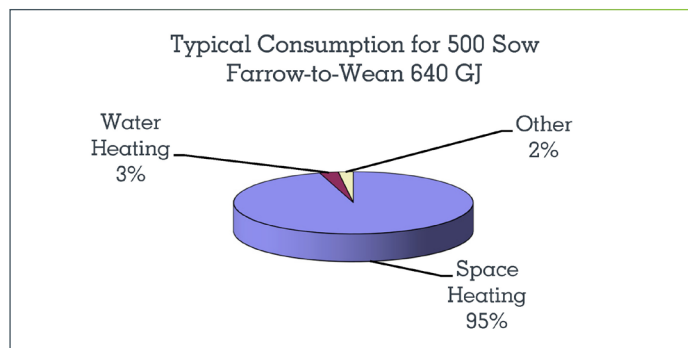


Figure 1. Natural Gas Usage and Distribution

Natural gas prices over the last five years have been unpredictable ranging from \$1.40 to \$10.50 per GJ (Figure 2). This equates to a range of \$851 to \$6,384 per year for a 500 sow farrow-to-wean operation.



Figure 2. Alberta Price for Natural Gas from 2008 to 2012
Source: Alberta Agriculture and Rural Development

Animal requirements

Temperature requirements for pigs vary with age and size, feeding level, health and the environmental conditions in the housing system used. Individual newborn piglets have a Lower Critical Temperature (LCT) in the region of 34 degree Celsius (°C).

Table 1 gives lower critical temperatures for pigs of various body weights depending on the rate of feed intake.

Table 1. Relation between body weight, feed intake, and lower critical temperature in groups of growing pigs at normal levels of feeding

Source: Canadian Farm Building Handbook

Body weight (kg)	Feed intake (kg/day)						
	0.5	1	1.5	2	2.5	3	3.5
	Lower critical temperature (°C)						
20	21	14					
40		20	14	8			
60			18	13	8		
80			16	11	7		
100			18	13	9		
120				15	11	8	

When the environmental temperature falls below the LCT, animal heat production increases 2-4% per °C. Air movement above 0.1 m/s, the use of individual pig stalls, or the presence of slotted or wet floors all increase the pig LCT. On the other hand, the LCT is reduced if you provide bedding and keep pigs in groups to permit them to huddle. As the temperature increases above the LCT, the rate of animal heat production decreases to a minimum. This range is called the thermoneutral range.

Animals should be kept in the thermoneutral range as listed in Table 2. Pigs tolerate and appear to even prefer a daily range in environmental temperature so long as the mean daily temperature is within the optimal range. Hahn, Nienaber and DeShazer recommend daily temperature cycles of ± 5 to 8°C which are permitted without adverse consequences on healthy animals. Rapid, marked drops in environmental temperature should be avoided.

Observing pigs will determine whether they are comfortable or not; pigs lying on their sides and slightly touching other pigs is an indication that pigs are comfortable. Hahn and Nienaber

Space Heating in Swine Production

determined the growth rate and feed conversion. Table 3 lists the recommended heating season setpoint temperatures for various rooms, age and body weights.

Table 2. The thermoneutral range for various sizes of pigs
Source: Recommended Code of Practice for the Care and Handling of Farm Animals, Agriculture and Agri-Food Canada

Stage of growth	Weight of pig (kg)	Range of zone (°C)
Piglet	Birth to 6 kg	34 to 24
Weaner	6 to 25	32 to 18
Grower	25 to 50	25 to 15
Finisher	50 to 100	25 to 15
Breeding stock	> 100	21 to 10

Table 3. Recommended setpoint temperatures for various ages
Source: Pork Production Reference Guide, Prairie Swine Centre

Room and body mass (kg)	Set point temperature °C		
	Solid floor	Slatted floor	Solid floor with straw
Dry sow	17	19	15
Farrowing	16	18	14
Weanling			
7	26	28	25
20	23	24	22
Grower/finisher (continuous)			
25-60	18	20	16
60-100	14	16	12
25-100	18	19	17
All in/all out			
25	21	23	20
30	20	22	18
35	19	20	17
40	17	19	16
45	16	17	15
50	15	15	14
55	14	15	13
60	14	15	12
70	14	15	11
80	14	15	10
90	14	15	10

Terminology

Lower Critical Temperature: The temperature below which an animal must increase its rate of metabolic heat production to maintain its body temperature (homeothermy). The LCT decreases as body weight and body fat increase.

Thermoneutral Zone: The range of environmental temperatures over which the heat produced by a 'warm-blooded' animal remains fairly constant. Hence, it is the range in which the animal is 'comfortable', having neither to generate extra heat to keep warm nor expend metabolic energy on cooling mechanisms such as panting.

Annual Fuel Utilization Efficiency (AFUE): The percentage of fuel the furnace converts to usable energy with the rest of the energy exhausted outside.

Applicable technology

Ventilation is used to balance temperature, humidity and gas and dust concentration. Space heating systems must work in coordination with ventilation systems to provide a good environment for swine. The systems for adding heat to the swine environment may be categorized into three main types: convective, radiant, and conductive heaters. Convective heaters discharge warm air into the room to raise the room air temperature directly. Radiant heaters do not directly heat or circulate air but rather warm surfaces that are in view of the heating element. With a conductive heater, heat is supplied to a material internally and then transferred by conduction to the exposed surface. Heating technology is usually categorized by the heat source or conduction liquid.

Electric - Since sows and piglets require different ambient temperature ranges, there is a need to create two environments in one room for farrowing facilities. Localized heat from lamps and pads are commonly used. The heat is also needed to dry the birth fluid on the piglets. Heat pads use less power, require less maintenance, block drafts, reduce fire hazards and provide more uniform heat distribution than lamps. Research at the University of Manitoba found using heat mats instead of lamps resulted in a daily saving of 2.8 kWh per crate. Heat pads require temperature feedback control systems to prevent excessive temperatures.

Hydronic - Hot water heating is a common and effective method for heating swine barns. Main components of the basic system are a boiler, circulating pump, distribution piping and radiators in the space to be heated. Radiators can be suspended on either the walls or ceiling under air inlets, or be above floor or in-floor. Regular cleaning of the radiators is required due to dust accumulation.

Space Heating in Swine Production

Forced air - Forced air heating systems (Figure 3) fired by natural gas or propane are economical but have to overcome potential high maintenance due to re-circulated dust and moisture. Some of the newer units are flueless and draw fresh air from outside. Uniform heat distribution may be a problem but it can be solved by using a recirculation system. Conventional forced air heaters are usually mid-efficiency with AFUE's in the range of 78 to 82%. New generation high efficiency forced air heaters use condensing and have AFUE's between 89 and 97%. They include a secondary heat exchanger to extract most of the heat remaining in the combustion by-products.



Figure 3. Typical forced air heating system
Source: Prairie Swine Centre

Case study: Most forced air furnaces installed prior to 1992 have an AFUE of 65%. Retrofitting furnaces with high efficiency units could increase the AFUE to 97%. For a 500 sow farrow-to-wean operation, this would reduce natural gas use by 211 GJ. Assuming the cost of natural gas is \$5.50 per GJ, this equates to a savings of \$1,161 per year.

Infrared radiant - Infrared radiant tube heaters (Figure 4) use the heat of combustion from several flame units to heat a length of pipe which then radiates the heat onto the pigs. The system only provides heat to the pigs and does not provide heat to warm air except for some re-radiation from the warmer surfaces. The air temperature can be kept lower resulting in lower heating costs. The heaters are normally flueless so heat is exhausted via the flue gases. A two-stage burner can further increase efficiencies. Material used for the heat reflector affects the performance of radiant heaters.



Figure 4. Typical infrared heater
Source: Prairie Swine Centre

Research at the Prairie Swine Centre observed infrared radiant heating consumed 60% less natural gas than a forced-air convection heater in a grow-finish room. The infrared radiant heating also provided more uniform heat distribution and had no adverse impact on the growth performance of the pigs.

Energy recovery

Air-to-air energy recovery systems used in swine barns are heat recovery devices that use warm exhaust air from barns to pre-warm incoming fresh air, thus recovering some heat from the exhaust air. Frost buildup is an issue that must be addressed with energy recovery systems operated in cold weather. Frost controls include reducing capacity to raise surface temperature, using defrost mode by reversing flow or preheating the outdoor air. The main types of heat exchangers are parallel flow, counter flow, cross flow and multiple-pass. The heat recovery efficiency is around 40%. Research by the Prairie Swine Centre found a reduction in energy use of 54% when using an air-to-air energy recovery device with a forced-air convection heater. The initial installed overall heating system cost is often lower when using air-to-air energy recovery devices because fuel-fired heating equipment can be reduced in capacity. Heat exchangers require regular maintenance due to the presence of humid, corrosive and dusty exhaust air. One manufacturer recommends washing once per week.

Energy sources

Conventional - Natural gas is by far the most common fuel source used for space heating of swine barns. Other fuel sources to consider if natural gas is not available are propane and biomass. Coal is not a preferred fuel source due to the higher emission of greenhouse gases. Sources of biomass can be wood and crop residues. The wood biomass industry is developed and wood pellets are available in Alberta.

Alternative heat

Active solar heating systems use solar energy collectors and additional electricity to power pumps or fans to distribute the solar energy. The heart of a solar collector is a black absorber which converts the sun's energy into heat. The heat is then transferred to another location for immediate heating or for storage for later use. The heat is transferred by circulating water, antifreeze or sometimes air. A recent test in Alberta on a poultry barn where the incoming ventilation air was heated using a dark colored south wall resulted in an average temperature rise for the incoming air of 6 to 8°C with an air temperature increase during daylight hours of as much as 30°C.

Space Heating in Swine Production

Geothermal heating systems use the moderate heat from the earth to heat a transfer liquid which carries the heat to the building. A heat pump is used to transfer and upgrade the heat from the liquid to the heating system in the building. Loop systems used to gather the heat from the earth can be vertical, horizontal or slinky coil ground-coupled. Each type of loop system has various advantages and disadvantages. Heat pumps are usually electric powered. For every unit of electricity the heat pump uses, it provides 3 to 4 units of heating energy. This gives a geothermal system up to 400% efficiency rating on average. Geothermal systems have a high initial cost but the underground loop systems will last up to 50 years. The price of electricity used to operate the heat pump greatly affects the economic return of a geothermal heating system. Research at the Prairie Swine Centre found a reduction in energy use of 45% when using a geothermal heating system with a heat pump compared to a forced-air convection heater.

Case study: An active solar heating system currently suitable for heating a swine barn is a solar air heater. The incoming ventilation air is heated using a dark colored south wall or roof of the barn. The air is pulled through tiny perforations in the outer cladding of the building by fans. A SolarWall solar air heating system was installed on two 18m x 30m swine nursery barns in Sherbrooke, Quebec. Use of the system displaced 30% of the propane usage on the farm. This translated into annual savings of over \$4,000 (based on 2007 propane prices) and a payback of five years.

Summary

On average, 95% of the natural gas consumption in a swine operation is attributed to space heating. Localized heat from lamps and pads are commonly used for piglets. Research at the University of Manitoba found using heat mats instead of lamps resulted in a daily saving of 2.8 kWh per crate. Efficiencies of forced air heaters have increased over the years. Retrofitting from low efficiency furnaces to ones with an AFUE of 97% in a 500 sow farrow-to-wean operation would result in a 211 GJ annual reduction of natural gas use. Infrared radiant tube heaters only provide heat to the pigs and do not provide heat to warm air except for some re-radiation from the warmer surfaces. The air temperature can be kept lower resulting in lower heating costs. An alternative heat source with good potential is an active solar heating system. The incoming ventilation air is heated using a dark colored south wall or roof of the barn. Recent tests have shown an average temperature rise for the incoming air of 6 to 8°C in normal sunlight with an air temperature increase during daylight hours of as much as 30°C.

References

- A Dictionary of Biology. (2004) Retrieved September 23, 2010, from <http://www.encyclopedia.com/doc/1O6-thermoneutralzone.html>.
- Agriculture and Agri-Food Canada. (1993). Recommended code of practice for the care and handling of farm animals: Pigs
- AgTech Centre. (2010). Energizing Tomorrow's Agriculture. AgTech Centre Innovator. 10:2.
- Alberta Agriculture and Rural Development. (2007). OnFarm Audit Reports.
- Andries, B. Heating and Ventilation in Swine Facilities, Prairie Swine Centre.
- Beshada, E., Q. Zhang and R. Boris (2006). A Cost Effective Heating Method for Piglets in Swine Farrowing Barns. CSBE/SCGAB 2006 Annual Conference. Edmonton, Alberta.
- Boris, R. E. (2008). Energy Savings with Heat Pads and Lighting. Banff Pork Seminar, Banff, Alberta.
- Curtis, S. E. (1983). Environmental management in animal agriculture, Iowa State University Press.
- Hahn, G. L., J. A. Nienaber and J. A. DeShazer (1987). "Air temperature Influences on Swine Performance and Behavior." Applied Engineering in Agriculture 3(2) (November): 295-302.
- Hahn, G. L. and J. A. Nienaber (1988). Performance and carcass composition of growing-finishing swine as thermal environment selection guides. Livestock Environment III, Constellation Hotel, Toronto, Ontario, Canada, American Society of Agricultural Engineers.
- Prairie Swine Centre (2000). Pork Production Reference Guide.
- Predicala, B., A. Alvarado, and L. Dominguez. 2012. Comparison of performance of radiant and forced-convection heating systems in swine grow-finish rooms – Part 2. Final Report to Alberta Agriculture & Rural Development, 29 pp.
- Research Branch Agriculture Canada. (1988). Canadian Farm Buildings Handbook.
- Stowell, R., T. Mader, and J. Gaughan. (2009). Livestock Energetics and Thermal Environmental Management, Chapter 8: Environmental Management. St. Joseph, Michigan, American Society of Agricultural and Biological Engineers.
- Trane Company. Trane Engineers Newsletter – Vol. 29, No. 5. Types of Indoor Heating Systems from <http://www.uniongas.com/index.asp>.
- Whitney, M. (2008). Conserve energy in the barn to reduce pork production costs. Pork Professor. Mankato, Minnesota.
- Zhang, D. Q. (2000). Performance Evaluation of Heat Mats in Swine Farrowing Facilities. Winnipeg, Manitoba, University of Manitoba.
- Zhang, Q., J. Wong-Li, M.L. Connor and H. Xin (2003). The Effect of Heat Lamp Usage on Performance of Piglets Shortly After Birth. Winnipeg, Manitoba, University of Manitoba.
- Zipperian, C. The Efficiency Rating Conundrum.